Exhibit D

Part 7

No Further Construction Necessary

- Where "the ordinary meaning of claim language as understood by a person of skill in the art may be readily apparent even to lay judges, [ ] claim construction in such cases involves little more than the application of the widely accepted meaning of commonly understood words."

  Phillips, 415 F.3d at 1314.

  - Jury will be instructed on agreed-to meanings:
    - "signal sample" means "a value of a signal at a certain point in time."
    - "noise" means "an unwanted disturbance in a signal."
  - "dependent" is well-known

    Joint Agreed Terms (Dkt. 74)
  - "Signal Dependent Noise" thus means "noise that is dependent on the signal"

CMU's "Media Noise" Argument Fails

- Specification relates "media noise" to recording

> Due to the signal dependent nature of media noise in magnetic recording, the functional form of joint conditional pdf $f(r_1, \ldots, r_N | a_1, \ldots, a_N)$ in (1) is different for different symbol sequences $a_1, \ldots, a_N$. Rather than making this

'839 Patent 4:24-26

- Confirms scope of patents beyond recording

> While the present invention has been described in conjunction with preferred embodiments thereof, many modifications and variations will be apparent to those of ordinary skill in the art. For example, the present invention may be used to detect a sequence that exploits the correlation between adjacent signal samples for adaptively detecting a sequence of symbols through a communications channel. The foregoing description and the following claims are intended to cover all such modifications and variations.

'839 Patent 13:51-59

Background: Other Signal Dependent Noise Sources

- Media Noise is not the only source of signal-dependent noise in other channels

Aspects of signal-dependent noise characterization

> The signal-dependent noise phenomenon is related to a number of physical processes such as images detected on film including natural scenes as well as many types of medical images. Magnetic tape recordings also have a signal-dependent noise component.[1] The origins of signal-dependent noise may depend on the form of the incoming signal as well as the detecting medium. When the acquisition is based on photon imaging, variations in incoming signal are signal dependent by definition due to the statistical nature of photons. This form of signal-dependent variation is often referred to as photon noise or Poisson noise. In radiographs, it is commonly referred to as quantum mottle or quantum noise. Similarly, photon noise is present in digital detectors such as charge-coupled device (CCD) and complementary metal-oxide semiconductor image sensors.[2] Film-grain noise is another source of signal-dependent noise. Film-grain noise, photon noise, as well as other corrupting influences may occur simultaneously in some acquisition processes with unequal influences.

- Magnetic Recording
  - Media Noise
- Photon Imaging
  - Photon Noise
  - Poisson Noise
  - Quantum Mottle
  - Film-Grain Noise
- Fiber Optics
  - Photodetector noise

Heine and Behera, *Aspects of signal-dependent noise characterization*, J. Opt. Soc. Am. A/Vo.23, No.4 806 (April 2006) (Proakis Supp. Exh. 1); *see also* Xi and Adal, *Integrated MAP Equalization and Turbo Product Coding for Optical Fiber Communications Systems*, IEEE Globecom (2005) (Proakis Supp. Exh. 2).

See Supp. Proakis Decl. at ¶¶ 7-8.

CMU's "Media Noise" Argument Fails

US 6,201,839 B1

While the present invention has been described in conjunction with preferred embodiments thereof, many modifications and variations will be apparent to those of ordinary skill in the art. For example, the present invention may be used to detect a sequence that exploits the correlation between adjacent signal samples for adaptively detecting a sequence of symbols through a communications channel. The foregoing description and the following claims are intended to cover all such modifications and variations.

'839 Patent 13:51-59

- "Signal dependent noise" is different in other communications channels

See supra, slides 61-66

Viterbi [algorithm]

Claim Term	CMU's Constructions	Marvell's Construction
Viterbi [algorithm] '839 Patent Claims 1, 4, 11, 16, 19, 23	an **iterative** algorithm that uses a trellis to determine the best sequence of hidden states (in this case, written symbols) based on observed events (in this case, observed readings that represent the written symbols), where the determined sequence is indicated by the best path through the trellis. CMU Brf. at 35-36 (CMU Reply at 10 n. 13)	an algorithm that uses a trellis to perform sequence detection by calculating branch metrics for each branch of the trellis, comparing the accumulated branch metrics for extensions of retained paths leading to each node of the trellis at a given time, and for each node, retaining only the path having the best accumulated metric. Marvell Brf. at 36-40

- The Dispute:
  - Does "Viterbi [algorithm]" refer to a well-known signal-processing algorithm (Marvell) or does the term broadly cover any algorithm for determining the best path through a trellis (CMU)?

Viterbi Algorithm

- CMU's construction for Viterbi algorithm is correct
  - There is one definition of this term in the "intrinsic evidence" found in the Fitzpatrick '532 Patent

'532 Patent

> The standard approach to implementing a Viterbi detector is to use the Viterbi algorithm to minimize the squared Euclidean distance between the sequence of noisy samples and all possible sequences of noiseless samples. The Viterbi algorithm is an iterative algorithm for determining the minimum metric path through a trellis, where the metric in this case is the squared Euclidean distance. During each

'532 Patent at col. 2:32-37.

CMU's "Viterbi-like" Arguments Fail

- CMU argues that "a '*Viterbi-like*' detector does not need to calculate the branch metric for every branch." CMU Brf. at 37

- Fails for Two Reasons:
  1. Parties agreed that "Viterbi-like" means "similar to and including the 'Viterbi algorithm.'" [Dkt. 74]
  2. The Viterbi Algorithm calculates metrics for each branch

distributed Gaussian noise with zero mean. The Viterbi algorithm is an iterative process of keeping track of the path with the smallest accumulated metric leading to each state in the trellis. The metrics of all of the paths leading into a particular state are calculated and compared. Then, the path with the smallest metric is selected as the survivor path. In this manner all paths which can not be part of the minimum metric path through the trellis are systematically eliminated.

U.S. Patent No. 5,689,532 7:64-8:4 (Marvell Exh. 37)

Sequential decoding is a sub-optimal but computationally efficient technique for decoding trellis based codes (esp. convolutional codes) [7], [8]. This technique searches through the trellis of the encoder efficiently to produce the most probable path. The Viterbi algorithm, on the other hand, searches through all the states in the trellis, and has exponential complexity with increasing constraint lengths of the encoder. The BCJR [9] decoder generates *a posteriori* probabilities for trellis based codes, but is at least twice as complex as the Viterbi decoder.

McLaughlin, *Sequential Turbo* Decoding, 36 IEEE Trans/ Magn/ at 2179 (2000) (Marvell Exh. 40)

As per claims 1, 4, 27-29, Fitzpatrick discloses a method for determining branch metric values for branches of trellis for a Viterbi-like detector (see figs.1, 2, 4) comprising: selecting a branch metric function for each of the branches at a certain time index (see col.2, lines 10-67 and

As per claims 6, 10 a method for generating a signal-dependent branch weight for branches of a trellis for a VITERBI-like detector (see figs. 1, 2, 4, 7) comprising: selecting a

As per claim 3, the system of Fitzpatrick inherently includes a branch metric function.

As per claims 6, 10 a method for generating a signal-dependent branch weight for branches of a trellis for a VITERBI-like detector (see figs. 1, 2, 4, 7) comprising: selecting a plurality of signal samples (see col.2, lines 10-67); calculating a first value representing a branch-dependent joint probability density function of a subset of said signal samples (see col.4, lines 5-67 and col.5, lines 15-40 and col.6, lines 40-55 and col.7, lines 55-67 and col.8, lines 1-21 and col.11, lines 55-67 and col.14, lines 10-67); calculating a second value representing a branch-dependent joint probability density function of a subset of said signal samples (see col.4, lines 5-67 and col.5, lines 15-40 and col.6, lines 40-55 and col.7, lines 55-67 and col.8, lines 1-21 and col.11, lines 55-67 and col.14, lines 10-67); calculating the branch weight from said first and second values (see col.4, lines 5-67 and col.5, lines 15-40 and col.6, lines 40-55 and col.7, lines

Viterbi Algorithm

United States Patent [19] **Fitzpatrick**

[11] **Patent Number: 5,689,532**

[45] **Date of Patent: *Nov. 18, 1997**

[54] **REDUCED COMPLEXITY EPR4 POST-PROCESSOR FOR SAMPLED DATA DETECTION**

[75] Inventor: **Kelly K. Fitzpatrick**, Mountain View, Calif.

Wood, "Turbo-PRML: A Compromise EPRML Detector", *IEEE Transactions of Magnetics*, vol. 29, No. 6, Nov. 1993.

Forney, "The Viterbi Algorithm", *Proceeding, of the IEEE*, vol. 61, No. 3, Mar. 1973, pp. 268–2278.

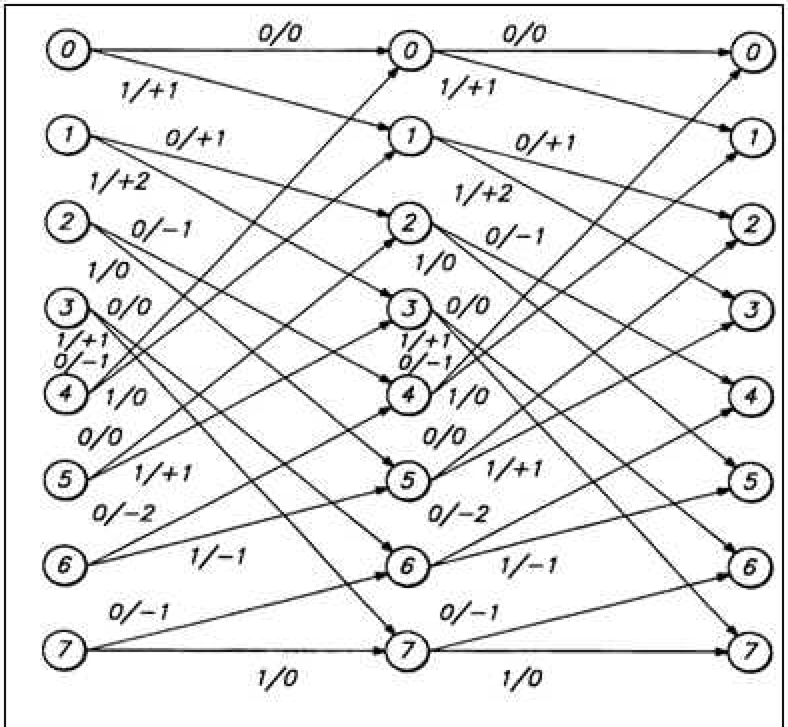

FIG. 4

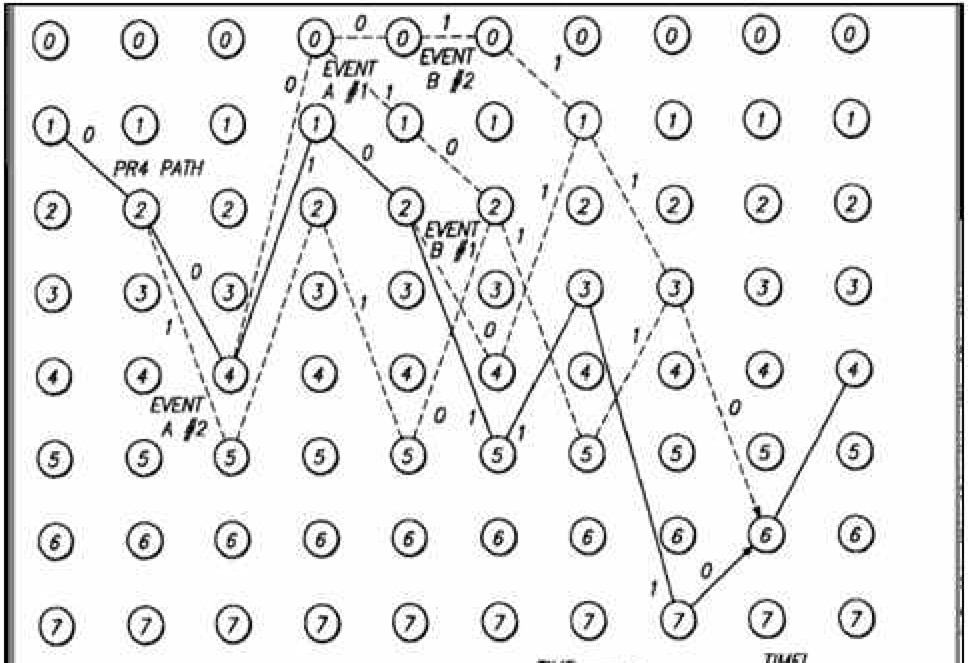

FIG. 7

function for each of the branches at a certain time index…; applying said selected function to a plurality of time variant signal samples to determine the metric values (see col. 2, lines 31-67 and col. 5, lines 45-67 and col. 7, lines 15-55 and col. 8, lines 1-22)."

Applicants submit that Fitzpatrick does not teach all of the elements independent claims 1, 4, 6, 10, 27, and 28 and, thus, those claims are not anticipated by Fitzpatrick.

Applicants have herein amended claims 1, 4, 27, and 28 to clarify that each of said selected functions is applied to a plurality of signal samples to determine the metric value corresponding to the branch for which the applied branch metric function was selected, wherein each sample corresponds to a different sampling time instant. Applicants submit that Fitzpatrick does not teach, among other steps, such a step. In particular, each of the branch metrics is not determined based on a plurality of signal samples.

Fitzpatrick does not specify the manner in which the branch metrics are computed. However, the Viterbi detector described in Fitzpatrick is described as an EPR4 Viterbi detector. Such a Viterbi detector computes a branch metric using:

$$\mathcal{M}_i(r_i, a_{i-3}, \ldots, a_i) = [r_i - y(a_{i-3}, \ldots, a_i)]^2$$

where r_i is a single waveform sample, not a plurality of time variant signal samples. Thus, because Fitzpatrick does not teach every step of claims 1, 4, 27, and 28, Applicants submit that claims 1, 4, 27, and 28 are not anticipated by Fitzpatrick. Also, Applicants submit that because claims 1 and 4 are not anticipated by Fitzpatrick, claims 2 and 3 and 5, which depend therefrom, respectively, are not anticipated by Fitzpatrick.

Independent claims 6 and 10, as amended, both recite the step of selecting a plurality of signal samples, wherein each sample corresponds to a different sampling time

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instant. As discussed hereinabove in connection with claims 1, 4, and 27-29, Fitzpatrick does not teach such a step. Thus, Applicants submit that independent claims 6 and 10, and dependent claims 7-9 which depend from claim 6, are not anticipated by Fitzpatrick.

The Examiner rejected claims 11-22 as being anticipated by U.S. Patent No. 5,862,192 to Huszar et al. The Examiner stated that Huszar et al. "discloses a method for detecting a sequence that exploits the correlation between adjacent signal samples for adaptively detecting a sequence of symbols stored on a high density magnetic recording device comprising the steps of: performing a Viterbi-like sequence detection…on a plurality of signal samples using a plurality of correlation sensitive branches…"

Applicants submit that Huszar et al. does not teach all of the elements in independent claims 11, 16, 19, and 20 and, thus, those claims are not anticipated by Huszar et al.

Independent claims 11 and 16 both recite the step of "performing a Virterbi-like sequence detection on a plurality of signal samples using a plurality of correlation sensitive branch metrics." Independent claim 19 recites, as an element, "a correlation-sensitive metric computation update circuit responsive to said noise statistics tracker circuit for recalculating a plurality of correlation-sensitive branch metrics from said noise covariance matrices, said branch metrics output to said Viterbi-like detector circuit."

Applicants submit that Huszar et al. does not show such a step or an element.

Huszar et al. discloses branch metrics that are not correlation sensitive. Instead, the branch metrics of Huszar et al. are path metrics that have the form of (*See* Huszar et al., col. 8, equation 17):

$$J = \Sigma_{\text{from } i=-\infty \text{ to } n} \mathcal{M}_i$$

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CMU's Construction Goes "Beyond Viterbi-like"

- CMU's construction encompasses any trellis-based algorithm

- The '180 Patent describes "beyond Viterbi-like:"

> The teachings of the present invention can be extended beyond Viterbi-like detectors to apply to turbo decoders, soft-decision detectors, and detectors utilizing the Viterbi algorithm, the BCJR algorithm, the Soft-Output Viterbi Algorithm (SOVA), and other similar algorithms.

'180 Patent 14:9-13

  - CMU's construction improperly covers some of these sequence detection algorithms

1

SOFT AND HARD SEQUENCE DETECTION IN ISI MEMORY CHANNELS

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. patent application Ser. No. 09/055,003, filed Apr. 3, 1998, which claims priority to Provisional Ser. No. 60/046,006, filed May 9, 1997, under 35 U.S.C. Section 119(e).

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH

This invention was supported in part by the National Science Foundation under Grant No. ECD-8907068. The United States Government has certain rights in this invention.

BACKGROUND OF THE INVENTION

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Turbo codes were introduced in 1993 and hold the promise of substantial coding gains over current coding algorithms, and their performance is within a fraction of a dB of the Shannon theoretical limit for additive white Gaussian noise channels. The basic idea in turbo decoding and other iterative decoding strategies is to pass "soft" information between several components of the decoder and the detector. In this context, the detector is the first device that processes data which is observed at the output of the communications channel. Classically, the detector is a hard-detection device which provides zeroes and ones at its output. A Viterbi detector is a typical example of such a hard detector. When iterative decoding is used, however, the detector is often a soft detector in which the outputs of the detector are reliability measures for bits transmitted through the communications channel. Because the detector is the first device that processes the channel output, the detector

communications channel. Classically, the detector is a hard-detection device which provides zeroes and ones at its output. A Viterbi detector is a typical example of such a hard detector. When iterative decoding is used, however, the detector is often a soft detector in which the outputs of the detector are reliability measures for bits transmitted through the communications channel. Because the detector is the

ness of this method has been demonstrated on real data in Zayad et al., "Comparison of Equalization and Detection for Very High-Density Magnetic Recording," IEEE INTERMAG Conference, New Orleans, April 1997.

These methods do not take into consideration the correlation between noise samples in the readback signal. These correlations arise due to noise coloring by front-end equalizers, media noise, media nonlinearities, and magnetoresistive (MR) head nonlinearities. This noise coloring causes significant performance degradation at high recording densities. Thus, there is a need for an adaptive correlation-sensitive maximum likelihood sequence detector which derives the maximum likelihood sequence detector (MLSD) without making the usual simplifying assumption that the noise samples are independent random variables.

samples, and written symbols;

FIG. 3A is an illustration of a branch metric computation module;

FIG. 3B is an illustration of an implementation of a portion of the branch metric computation module of FIG. 3A;

FIG. 4 is an illustration of one cell of a PR4 trellis;

FIG. 5 is an illustration of a detected path in a PR4 trellis;

FIG. 6 is a block diagram of a preferred embodiment of a method for signal detection;

FIG. 7 is an illustration of PR4 detection results at a 4.4a/symbol;

FIG. 8 is an illustration of EPR4 detection results at a 4.4a/symbol;